

The University of Chicago

ANATOMY OF THE PARSNIP ROOT

A PART OF A DISSERTATION SUBMITTED TO
THE GRADUATE FACULTY IN CANDIDACY FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF BOTANY
1930

By
WINIFRED CAROLINE WARNING

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Three regions appear in the young seedling; root, hypocotyl, and cotyledons. The junction of root and hypocotyl is easily distinguished, being marked by an enlargement of the hypocotyl and an abrupt constriction of the root. Small ephemeral root hairs develop, and secondary roots may diverge from the hypocotyl.

The primary root falls under Janczewski's third type, plerome, and periblem defined, with the periblem overlying the plerome, while calyptragen and dermatogen are differentiated together.

Since the parsnip seed is slow in germination, many of the earlier stages must be studied while the plant is still within the fruit coat. A transverse section through the proximal part of a root which has been in the ground three days shows a mass of undifferentiated cells. At four days the epidermis, consisting of a single layer of rounded cells, is differentiated. At five days the pericycle is easily distinguished, which in its earlier stages is composed of cells hexagonal in outline and larger than any of the other cells. Between the fifth and sixth day, the cells of the pericycle divide frequently. The walls following these divisions may be either oblique, tangential, or vertical. Eight different directions in new walls which may be laid down have been observed. The vertical and obliquely longitudinal divisions serve to increase the number of cells in the pericycle, the tangential divisions produce endodermal cells, and the oblique divisions which pass diagonally across the cell, cutting off an irregular quadrilateral cell on one side and leaving a larger hexagonal cell on the other side, form oil ducts.

The first oil ducts which are differentiated, and in which pericyclic cells alone are involved, are formed in the following manner: beginning with the central oil ducts, which are located at points on the pericycle 180 degrees apart, from two adjoining sides of two adjacent cells, quadrilateral cells are cut off, to right from one cell and to left from the other; thus leaving two of the small quadrilateral and two of the larger hexagonal cells bounding the central oil ducts. Cell divisions follow in the cells on either side of the central ducts, quadrilateral cells are cut off to the right on one side and to the left on the other, until an arc of from ten to eleven cells is formed on either side of the root. There are four or five cells of the pericycle between these arcs, which do not form oil ducts and retain their hexagonal outline.

The endodermis and cortex are differentiated as soon as the oil ducts are formed. The former consists of a single layer, the latter of seven to ten rows of cells, more or less hexagonal in shape, and with relatively large intercellular spaces.

Immediately after the oil ducts have been formed, two proto-phloem points are differentiated from the mass of procambial cells bounded by the pericycle. They are 180 degrees apart and are situated directly opposite the middle cells of the non-oil duct forming cells of the pericycle. Proto- and metaphloem develop rapidly.

Following the proto- and metaphloem two protoxylem points are differentiated from the procambial cells. They lie directly opposite the central oil ducts and are separated from them by a few rows of parenchyma. The primary xylem is diarch and this condition is practically universal in the root, for in hundreds of roots which were sectioned only two exceptions were found. These had triarch primary xylem and triple cotyledons were associated

with it. The primary xylem and phloem are separated by a band of parenchyma several cells in thickness.

Secondary thickening begins at an early stage, just as the first leaves begin to enlarge, or about twenty days after the seed has been planted. A cambium is differentiated from the band of parenchyma between xylem and phloem by tangential divisions, opposite the protophloem points and proliferates to right and left. The pericycle proliferates and connects the cambium to form the cambial ring. Much of the secondary xylem and phloem remains in a parenchymatous condition.

Secondary growth naturally pushes the endodermis, cortex, and epidermis outward and when the pressure from within is sufficient, they rupture and slough off. The pericyclic oil ducts are also pushed outward, and are disintegrated after persisting for a short time. After these outer tissues have sloughed off, xylem and phloem parenchyma become very active. Cells which heretofore have shown no remarkable growth, divide and increase enormously in size, so that there is an unusual proliferation of cells. Both xylem and phloem parenchyma show many starch grains. A periderm, which was initiated before the rupturing of the tissues, is formed by the pericycle.

The primary xylem remains at the center of the stele for a short time after the outer tissues have sloughed off, then the enormous growth of the xylem parenchyma separates it from the secondary xylem, and parenchyma cells wedge between the primary cells as the former increase in size, the latter are pushed apart. The protoxylem points disintegrate and it becomes impossible to distinguish the metaxylem cells.

The phloem parenchyma is more active and abundant than the xylem parenchyma. Immediately after the sloughing off of the

outer tissues, the primary and early secondary phloem groups can be seen, 180 degrees apart, near the periderm and between them phloem parenchyma appears. The sieve tubes and companion cells have become fibrous because of the thickening of their walls.

When the outer tissues are rupturing, cork is formed from the pericycle as previously stated. It is laid down in the usual way by the phellogen. The phellem sloughs off continually and the cork is thin, usually not more than three or four cells thick.

In the secondary xylem the parenchyma and vessels have ray arrangement at first, but the parenchyma cells increase enormously in size, and as they grow, wedge between the vessels and force them apart, so that, in the older portions, the vessels are scattered.

The sieve tubes and companion cells of the secondary phloem become fibrous soon after they are differentiated from the cambium, and rays of phloem parenchyma are differentiated between rays of fibers, but after a certain amount of growth, the parenchyma forces irregular groups of the fibers apart, and they are scattered through the outer parenchyma; where, in the older portions, all resemblance to ray arrangement is entirely lost.

The first oil ducts are laid down by the pericycle, as previously described, following these others are laid down in secondary tissue. They are differentiated in regular order, but as growth proceeds, the parenchyma forces them apart and they are scattered through it. The oil ducts are schizogenous, but at times they anastomose and become schizolysigenous.

The first group of secondary roots is differentiated before disintegration of the outer tissues occurs. The initials are differentiated in the meristem formed by the non-oil duct forming pericyclic cells. The roots cannot follow the ordinary method of

development, because the pericyclic oil ducts are opposite the protoxylem points and these constitute a barrier, between them and the xylem. The conductive tissue which connects the conductive tissue of the primary root with that of the secondary is differentiated in the parenchyma which lies between the primary xylem and phloem and is opposite the initial cells. There are four places in the pericycle where secondary roots may differentiate, and they differentiate here, but not all at the same level, for in any transverse section, only one root is seen. When disintegration of the outer tissues occurs, the first group of secondary roots disappears, and a second group is differentiated. The meristem of this second group and of all succeeding groups is differentiated in the cork cambium near the conductive tissue which was laid down when the first group of secondary roots was developed. The cork cambium becomes very meristematic when new roots are about to be differentiated and there is much cell division. The new cells do not resemble the cork cambium but are parenchymatous and it is in these cells that the root initials appear. Xylem is differentiated from the cork cambium and a connection with the conductive tissue is established. The secondary group of secondary roots is as ephemeral as the first, and is followed by a series of roots differentiating like the second group, successive new groups appearing as the older disappear. Occasionally a secondary root does not disintegrate and a fairly large persistent root develops. The disintegration of secondary roots is particularly noticeable in the spring when the taproot is entering on its second year of growth. This sloughing is followed by the appearance of mats of roots, which differentiate where the previous groups have disintegrated, and while a few are found on the lower part of the taproot, by far the greater number is on the upper portion.

The secondary root differs from the primary in three particulars; there is a greater amount of xylem as compared with the other tissues, and in the xylem there are many vessels and a small amount of parenchyma. The primary xylem may be diarch, or as frequently triarch, but seldom tetrarch as contrasted with the practically constant diarch condition of the primary root.

During the second year the stored food in the taproot is used in producing flowers and fruit, and xylem and xylem parenchyma become heavily lignified. A narrow band of cambium persists, and the phloem, as the stored food is transported from it, shrinks and a relatively narrow band of small cells remains.

SUMMARY

1. The mature root of Pastinaca sativa represents the true primary root and the lower part of hypocotyl.

2. The primary root falls under Janczewski's third type.

3. Tissues are differentiated in the following order: epidermis, pericycle, pericyclic oil ducts, endodermis, and cortex, primary phloem, primary xylem, the latter being diarch.

4. Secondary thickening begins early, and is followed by disintegration of all the outer tissues, including the pericyclic oil ducts.

5. Proliferation of both xylem and phloem parenchyma follows sloughing of the outer tissues and a periderm is differentiated from the pericycle.

6. Secondary roots are differentiated in the pericycle opposite parenchymatous bands which lie between primary xylem and phloem. These roots disintegrate with the outer tissues.

7. Groups of roots following the first group are differentiated in the cork cambium.

8. During the second year, the food stored in the taproot is used to produce flowers and fruit. The xylem becomes heavily lignified and the phloem cells shrink as food is taken from them.

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